We claim:

1. An optical router for routing wavelength channels received in bundles of wavelength channels, the router comprising:

a plurality of wavelength filters, one filter of the plurality of wavelength filters per bundle, each filter of the plurality of wavelength filters being capable of separating one or more wavelength channels from the bundle associated with the filter;

a plurality of wavelength converters, one converter of the plurality of wavelength converters per bundle, each converter being capable of receiving an add wavelength channel and converting the received add wavelength channel to a transformed wavelength;

a plurality of multiplexing units, one multiplexing unit of the plurality of multiplexing units per bundle, each multiplexing unit of the plurality of multiplexing units being capable of multiplexing at least a subset of channels of the bundle associated with said each multiplexing unit and the add wavelength channel converted by the converter associated with the bundle that is associated with said each multiplexing unit;

a first spatial switching fabric comprising a plurality of inputs and a plurality of outputs, the inputs of the first spatial switching fabric being coupled to the plurality of wavelength filters to receive the separated one or more wavelength channels; and

a plurality of channel combiners, one channel combiner of the plurality of channel combiners per multiplexing unit of the plurality of multiplexing units, each channel combiner of the plurality of channel combiners being coupled to a different one of the outputs of the plurality of outputs of the first spatial switching fabric, said each channel combiner being capable of receiving and multiplexing channels received from the corresponding output of the plurality of outputs of the first spatial switching fabric and the channels multiplexed by the multiplexing unit associated with said each channel combiner.

2. An optical router according to claim 1, wherein said each filter of the plurality of wavelength filters comprises a tunable band pass filter capable of separating different one or more wavelength channels.

3. An optical router according to claim 2, wherein said each converter of the plurality of wavelength converters comprises a tunable pump source capable of producing pump output at different wavelengths to enable said each converter to convert the received add wavelength channel to different transformed wavelengths.

4. An optical router according to claim 1, wherein said each wavelength filter of the plurality of wavelength filters comprises a circulator having consecutive first, second, and third ports, and a Bragg grating coupled to the third port of the circulator.

5. An optical router according to claim 4, wherein the Bragg grating of said each wavelength filter is a tunable Bragg grating capable of being adjusted to reflect different wavelengths.

6. An optical router according to claim 1, wherein said each wavelength filter of the plurality of wavelength filters comprises:

a fused fiber optical power splitter comprising an input path capable of receiving the bundle associated with said each wavelength filter, a pass-through output path

for outputting at least the subset of channels of the bundle associated with said each wavelength filter, and a first separated output path capable of outputting the one or more wavelength channels separated from the bundle associated with said each wavelength filter; and

a first band pass filtering element coupled to the first separated output path so that the one or more wavelength channels separated from the bundle associated with said each wavelength filter pass through the first band pass filtering element, the first band pass filtering element having a first passband.

7. An optical router according to claim 6, wherein:

the fused fiber optical power splitter of said each wavelength filter further comprises a second separated output path capable of outputting the one or more wavelength channels separated from the bundle associated with said each wavelength filter; and

said each wavelength filter further comprises a second band pass filtering element coupled to the second separated output path so that the one or more wavelength channels separated from the bundle associated with said each wavelength filter pass through the second band pass

filtering element, the second band pass filtering element having a second passband.

8. An optical router according to claim 6, wherein said each wavelength filter further comprises active fiber filler in the first separated output path, the active fiber filler being for amplifying the one or more wavelength channels separated from the bundle associated with said each wavelength filter.

9. An optical router according to claim 6, wherein said each wavelength filter further comprises a pass-through band reject filtering element coupled to the pass-through output path for removing the one or more wavelength channels separated from the bundle associated with said each wavelength filter from the subset of channels of the bundle associated with said each wavelength filter.

10. An optical router according to claim 9, wherein:

the pass-through band reject filtering element of said each wavelength filter comprises a tunable pass through filtering element capable of being adjusted to reject different wavelengths; and

the first band pass filtering element comprises a first tunable filtering element capable of being adjusted to transmit different wavelengths.

11. An optical router according to claim 1, wherein said each converter of the plurality of wavelength converters comprises a difference frequency mixer.

12. An optical router according to claim 11, wherein:

said each filter of the plurality of wavelength filters comprises a tunable band pass filter capable of separating different one or more wavelength channels; and

the difference frequency mixer of said each converter of the plurality of wavelength converters comprises a tunable pump source capable of producing pump output at different wavelengths to enable said each converter to convert the received add wavelength channel to different transformed wavelengths.

13. An optical router according to claim 1, wherein said each converter of the plurality of wavelength converters comprises a cross-gain modulator.

14. An optical router according to claim 13, wherein:

said each filter of the plurality of wavelength filters comprises a tunable band pass filter capable of separating different one or more wavelength channels; and

the cross-gain modulator of said each converter of the plurality of wavelength converters comprises a tunable pump source capable of producing pump output at different wavelengths to enable said each converter to convert the received add wavelength channel to different transformed wavelengths.

15. An optical router according to claim 1, wherein said each converter of the plurality of wavelength converters comprises a cross-phase modulator.

16. An optical router according to claim 13, wherein:

said each filter of the plurality of wavelength filters comprises a tunable band pass filter capable of separating different one or more wavelength channels; and

the cross-phase modulator of said each converter of the plurality of wavelength converters comprises a tunable

pump source capable of producing pump output at different wavelengths to enable said each converter to convert the received add wavelength channel to different transformed wavelengths.

17. An optical router according to claim 1, wherein said each converter of the plurality of wavelength converters comprises a four-wave mixer.

18. An optical router according to claim 13, wherein:

said each filter of the plurality of wavelength filters comprises a tunable band pass filter capable of separating different one or more wavelength channels; and

the four-wave mixer of said each converter of the plurality of wavelength converters comprises a tunable pump source capable of producing pump output at different wavelengths to enable said each converter to convert the received add wavelength channel to different transformed wavelengths.

19. An optical router according to claim 1, further comprising a plurality of power equalizers, one equalizer per wavelength converter of the plurality of wavelength

converters, each equalizer being interposed between the converter associated with said each equalizer and the multiplexing unit corresponding to the wavelength converter associated with said each equalizer.

20. An optical router according to claim 1, wherein said each multiplexing unit comprises a circulator.

21. An optical router according to claim 3, wherein said each multiplexing unit comprises a circulator.

22. An optical router according to claim 1, wherein said each multiplexing unit comprises a fused fiber optical power splitter.

23. An optical router according to claim 3, wherein said each multiplexing unit comprises a fused fiber optical power splitter.

24. An optical router according to claim 1, further comprising a second spatial switching fabric comprising a plurality of inputs and a plurality of outputs, one input of the plurality of inputs of the second spatial switching fabric per channel combiner of the plurality of channel

combiners, each input of the plurality of inputs of the second spatial switching fabric being coupled to the channel combiner associated with said each input of the plurality of inputs of the second spatial switching fabric to receive the channels multiplexed by the channel combiner associated with said each input of the plurality of inputs of the second spatial switching fabric.

25. An optical router according to claim 24, wherein:

said each filter of the plurality of wavelength filters comprises a tunable band pass filter capable of separating different one or more wavelength channels; and

said each converter of the plurality of wavelength converters comprises a tunable pump source capable of producing pump output at different wavelengths to enable said each converter to convert the received add wavelength channel to different transformed wavelengths.

26. An optical router according to claim 24, further comprising:

a plurality of optical amplifiers, one amplifier of the plurality of amplifiers per channel combiner, each

amplifier of the plurality of amplifiers being interposed between the channel combiner associated with said each amplifier and the input of the plurality of inputs of the second spatial switching fabric associated with the channel combiner that is associated with said each amplifier.

27. An optical router according to claim 24, further comprising:

a plurality of optical switches, one switch of the plurality of switches per wavelength filter of the plurality of wavelength filters, each switch of the plurality of switches comprising an input, a first switch output, and a second switch output, said each switch being capable of receiving the bundle associated with the filter that is associated with said each switch and selectively transmitting the bundle associated with the filter that is associated with said each switch to the first or the second switch output of said each switch;

a redundant path channel combiner comprising an output and inputs coupled to the second switch outputs of the plurality of optical switches;

a redundant path wavelength filter capable of separating one or more wavelength channels from one of the bundles of wavelength channels;

a redundant path wavelength converter capable of receiving a redundant path add channel and converting the received redundant path add channel to a different wavelength;

a redundant path multiplexing unit coupled to the redundant path wavelength filter and to the redundant path wavelength converter, the redundant path multiplexing unit being capable of multiplexing at least a subset of channels of the one of the bundles of wavelength channels and the converted redundant path add channel;

wherein:

the plurality of channel combiners comprises a first channel combiner, the first channel combiner being coupled to the redundant path multiplexing unit; and

the first channel combiner is capable of multiplexing the channels received by the first channel combiner from the output of the first spatial switching fabric corresponding to the first channel combiner, the channels multiplexed by the multiplexing unit associated with the

first channel combiner, and the channels multiplexed by the redundant path multiplexing unit.

28. An optical router according to claim 27, wherein said each converter of the plurality of wavelength converters comprises a difference frequency mixer.

29. An optical router according to claim 28, wherein:

said each filter of the plurality of wavelength filters comprises a tunable band pass filter capable of separating different one or more wavelength channels; and

the difference frequency mixer of said each converter of the plurality of wavelength converters comprises a tunable pump source capable of producing pump output at different wavelengths to enable said each converter to convert the received add wavelength channel to different transformed wavelengths.

30. An optical router according to claim 27, wherein said each converter of the plurality of wavelength converters comprises a cross-gain modulator.

31. An optical router according to claim 30, wherein:

said each filter of the plurality of wavelength filters comprises a tunable band pass filter capable of separating different one or more wavelength channels; and

the cross-gain modulator of said each converter of the plurality of wavelength converters comprises a tunable pump source capable of producing pump output at different wavelengths to enable said each converter to convert the received add wavelength channel to different transformed wavelengths.

32. An optical router according to claim 27, wherein said each converter of the plurality of wavelength converters comprises a cross-phase modulator.

33. An optical router according to claim 32, wherein:

said each filter of the plurality of wavelength filters comprises a tunable band pass filter capable of separating different one or more wavelength channels; and

the cross-phase modulator of said each converter of the plurality of wavelength converters comprises a tunable

pump source capable of producing pump output at different wavelengths to enable said each converter to convert the received add wavelength channel to different transformed wavelengths.

34. An optical router according to claim 27, wherein said each converter of the plurality of wavelength converters comprises a four-wave mixer.

35. An optical router according to claim 34, wherein:

said each filter of the plurality of wavelength filters comprises a tunable band pass filter capable of separating different one or more wavelength channels; and

the four-wave mixer of said each converter of the plurality of wavelength converters comprises a tunable pump source capable of producing pump output at different wavelengths to enable said each converter to convert the received add wavelength channel to different transformed wavelengths.

36. An optical router according to claim 1, wherein said each filter of the plurality of wavelength filters comprises a tunable band pass filter characterized by a

passband with an adjustable bandwidth and an adjustable center wavelength, whereby said each filter of the plurality of wavelength filters is capable of separating a first wavelength channel of the one or more wavelength channels at different wavelengths and with variable channel separation.

37. An optical router according to claim 36, wherein said each converter of the plurality of wavelength converters comprises a tunable pump source capable of producing pump output at different wavelengths to enable said each converter to convert the received add wavelength channel to different transformed wavelengths.

38. An optical router for routing wavelength channels received in bundles of wavelength channels, the router comprising:

a plurality of wavelength filters, one filter of the plurality of wavelength filters per bundle, each filter of the plurality of wavelength filters being capable of separating one or more wavelength channels from the bundle associated with the filter;

a plurality of wavelength converters, one converter of the plurality of wavelength converters per bundle, each converter being capable of receiving an add wavelength channel and converting the received add wavelength channel to a transformed wavelength;

a first spatial switching fabric comprising a plurality of inputs and a plurality of outputs, the inputs of the first spatial switching fabric being coupled to the plurality of wavelength filters to receive the separated one or more wavelength channels;

a plurality of multiplexing units, one multiplexing unit of the plurality of multiplexing units per bundle, each multiplexing unit of the plurality of multiplexing units being coupled to a respective output of the plurality of outputs of the first spatial switching fabric, said each multiplexing unit of the plurality of multiplexing units being capable of multiplexing at least a subset of channels of the bundle associated with said each multiplexing unit, the add wavelength channel converted by the converter associated with the bundle that is associated with said each multiplexing unit, and channels received from the respective output of the

plurality of outputs of the first spatial switching fabric.

39. An optical router according to claim 38, wherein said each filter of the plurality of wavelength filters comprises a tunable band pass filter capable of being adjusted to separate different one or more wavelength channels.

40. An optical router according to claim 39, wherein said each converter of the plurality of wavelength converters comprises a tunable pump source capable of producing pump output at different wavelengths to enable said each converter to convert the received add wavelength channel to different transformed wavelengths.

41. An optical router according to claim 38, wherein said each multiplexing unit of the plurality of multiplexing units comprises a fused fiber optical power splitter.

42. An optical router according to claim 41, wherein the fused fiber optical power splitter of said each multiplexing unit of the plurality of multiplexing units

comprises active fiber filler capable of amplifying the wavelength channels multiplexed by said each multiplexing unit of the plurality of multiplexing units.

43. A router comprising:

a first wavelength selection module comprising an input port capable of receiving a first plurality of wavelength channels, a first wavelength filter capable of separating a first separated channel from the first plurality of wavelength channels, and a first pass-through output port for outputting wavelength channels of the first plurality of wavelength channels;

a second wavelength selection module comprising an input port capable of receiving a second plurality of wavelength channels, a second wavelength filter capable of separating a second separated channel from the first plurality of wavelength channels, and a second pass-through output port for outputting wavelength channels of the second plurality of wavelength channels;

a first wavelength conversion module comprising a first wavelength converter capable of receiving a first add channel at a first add wavelength and converting the first add channel to a first converted wavelength, a first

multiplexing unit coupled to the first pass-through port and to the first wavelength converter, the first multiplexing unit being capable of multiplexing the wavelength channels of the first plurality of wavelength channels received from the first pass-through port and the converted first add channel;

a second wavelength conversion module comprising a second wavelength converter capable of receiving a second add channel at a second add wavelength and converting the second add channel to a second converted wavelength, a second multiplexing unit coupled to the second pass-through port and to the second wavelength converter, the second multiplexing unit being capable of multiplexing the wavelength channels of the second plurality of wavelength channels received from the second pass-through port and the converted second add channel;

a first spatial switching fabric comprising a first input coupled to the first wavelength selection module to receive the first separated channel, a second input coupled to the second wavelength selection module to receive the second separated channel, and a plurality of outputs comprising a first output and a second output;

a first channel combiner coupled to the first output of the plurality of outputs of the first spatial switching fabric and to the first wavelength conversion module, the first channel combiner being capable of receiving and multiplexing wavelength channels from the first output of the first spatial switching fabric and the channels multiplexed by the first multiplexing unit; and

a second channel combiner coupled to the second output of the plurality of outputs of the first spatial switching fabric and to the second wavelength conversion module, the second channel combiner being capable of receiving and multiplexing wavelength channels from the second output of the first spatial switching fabric and the channels multiplexed by the second multiplexing unit.

44. A router according to claim 43, wherein:

the first wavelength filter comprises a first tunable band pass filtering element capable of being adjusted to separate the first separated channel in a range of wavelengths; and

the second wavelength filter comprises a second tunable band pass filtering element capable of being

adjusted to separate the second separated channel in a range of wavelengths.

45. A router according to claim 44, wherein the first wavelength converter comprises a tunable pump source capable of producing pump output at different wavelengths to enable said each converter to convert the first add channel to a first converted wavelength in a range of wavelengths.

46. An optical wavelength router comprising:

first wavelength selection means for receiving a first plurality of wavelength channels from a first in fiber, and for selectively separating at least a first channel from the first plurality of wavelength channels;

second wavelength selection means for receiving a second plurality of wavelength channels from a second in fiber, and for selectively separating at least a second channel from the second plurality of wavelength channels;

first wavelength conversion means for receiving a first add wavelength channel at a first add wavelength and converting the first add wavelength channel to a first transformed wavelength;

second wavelength conversion means for receiving a second add wavelength channel at a second add wavelength and converting the second add wavelength channel to a second transformed wavelength;

first wavelength multiplexing means coupled to the first wavelength conversion means and to the first wavelength selection means, the first wavelength multiplexing means being for multiplexing at least a first subset of wavelength channels of the first plurality of wavelength channels and the converted first add wavelength channel;

second wavelength multiplexing means coupled to the second wavelength conversion means and to the second wavelength selection means, the second wavelength multiplexing means being for multiplexing at least a second subset of wavelength channels of the second plurality of wavelength channels and the converted second add wavelength channel;

first spatial switching means comprising a first input, a second input, a first output, and a second output, the first spatial switching means being for routing wavelength channels from the inputs of the first

spatial switching means to the outputs of the first spatial switching means;

first channel combiner means for combining wavelength channels appearing at the first output of the first spatial switching means and the wavelength channels multiplexed by the first wavelength multiplexing means; and

second channel combiner means for combining wavelength channels appearing at the second output of the second spatial switching means and the wavelength channels multiplexed by the second wavelength multiplexing means.

47. An optical wavelength router according to claim 46, wherein:

the first wavelength selection means comprises first tunable band pass filter means capable of being adjusted to separate the first channel in a range of wavelengths; and

the second wavelength selection means comprises second tunable band pass filter means capable of being adjusted to separate the second channel in a range of wavelengths.

48. An optical wavelength router according to claim 47, wherein the first wavelength conversion means comprises a first tunable wavelength conversion means for converting the first add wavelength channel to the first transformed wavelength in a range of wavelengths.

49. An optical wavelength router according to claim 48, wherein the first tunable wavelength conversion means comprises a difference frequency mixer means for wavelength conversion.

50. An optical wavelength router according to claim 48, wherein the first tunable wavelength conversion means comprises a cross-gain modulator means for wavelength conversion.

51. An optical wavelength router according to claim 48, wherein the first tunable wavelength conversion means comprises a cross-phase modulator means for wavelength conversion.

52. An optical wavelength router according to claim 48, wherein the first tunable wavelength conversion means

comprises a four-wave mixer means for wavelength conversion.

53. An optical wavelength router according to claim 48, further comprising second spatial switching means comprising a first input, a second input, and a plurality of outputs, the first input of the second spatial switching means being coupled to the first channel combiner means to receive the wavelength channels combined by the first channel combiner means, the second input of the second spatial switching means being coupled to the second channel combiner means to receive the wavelength channels combined by the second channel combiner means, the second spatial switching means being for routing the wavelength channels combined by the first and the second channel combiner means from the first and second inputs of the second spatial switching means to the plurality of outputs of the second spatial switching means.

54. An optical wavelength router according to claim 53, further comprising means for providing router path fault protection through redundancy.

55. An optical wavelength router according to claim 54, further comprising:

first means for amplifying wavelength channels interposed between the first channel combiner means and the first input of the second spatial switching means; and

second means for amplifying wavelength channels interposed between the second channel combiner means and the second input of the second spatial switching means.

56. An optical wavelength router according to claim 46, wherein:

the first wavelength selection means comprises first tunable band pass filter means characterized by a first adjustable center wavelength and a first adjustable bandwidth; and

the second wavelength selection means comprises second tunable band pass filter means characterized by a second adjustable center wavelength and a second adjustable bandwidth.

57. An optical wavelength router according to claim 56, wherein the first wavelength conversion means comprises a first tunable wavelength conversion means for

converting the first add wavelength channel to the first transformed wavelength in a range of wavelengths.